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(54) Method for injection-moulding of a product

(57) A method is described for injection-moulding a product by means of the so-called gas-injection method. A special feature of the method is that in addition to the forming of a first gas volume (41) and a second gas volume (42) in a product cavity (10) by injecting gas via a first gas inlet (51) and a second gas inlet (52), an alternating pressure difference is applied between said gas volumes such that the magnitude of the gas volumes alternately increases and decreases in order to control the distribution of material injected.

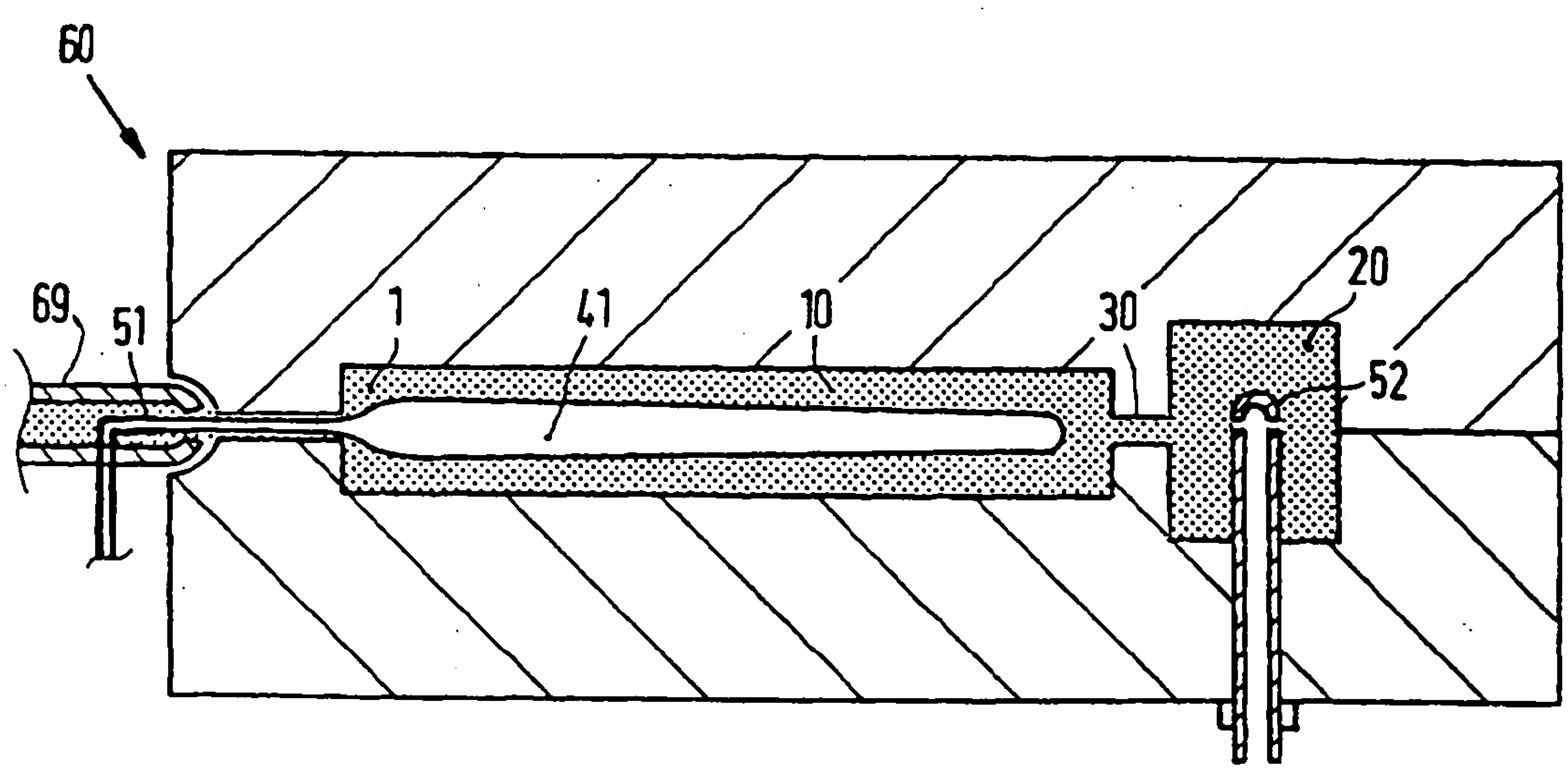

FIG.9

Description

[0001] The invention relates to a method for injection-moulding a product, including the steps of: injecting an amount of a liquid material into a mould having a product cavity defining the contours of the product, forming a first gas volume and a second gas volume in the product cavity by injecting gas *via* a first gas inlet and a second gas inlet, respectively, which first and second gas inlet are in communication with the product cavity, allowing the liquid matenal in the product cavity to solidify, and removing the product from the product cavity.

[0002] Such a method is known from US-A-5,098,637 which describes the injection-moulding of a hollow product. In accordance with the known method a hot and consequently liquid plastic is injected into a product cavity, after which gas is injected into the product cavity *via* a first and a second gas inlet, which inlets terminate in the product cavity. The injection of gas *via* two gas inlets results in two gas volumes which are separated by a volume of liquid plastic. The gas urges a part of the liquid plastic into a spill cavity, resulting in two voids in the product, which voids are separated by a plastic wall. Finally, the plastic solidifies by cooling, after which the product is taken out of the product cavity and the plastic stemming from the spill cavity is removed. The volume of the spill cavity is adjusted by means of a setscrew prior to moulding. A drawback of this method is the absence of an adjustment possibility during injection-moulding.

[0003] It is an object of the invention to provide a method by means of which it is possible to control the distribution of a quantity of material injected into the mould between the product cavity and the spill cavity.

[0004] To achieve this object the method in accordance with the invention is characterised in that an alternating pressure difference is applied between the gas volumes such that the magnitude of the gas volumes increases and decreases.

[0005] It is also possible to drive the still liquid material to and fro between two gas inlets by alternately reversing the sign of the pressure difference if both gas inlets terminate in the product cavity at some distance from one another. A thin layer of the still liquid material will then each time settle on the already solidified wall of the hollow space in the product. Thus, the liquid material will ultimately be spread over this wall so that one hollow space is formed.

[0006] The invention further relates to a mould for injection-moulding of a product, which mould can be used into the method in accordance with the invention.

[0007] Furthermore the invention relates to a product manufactured by the method in accordance with the invention.

[0008] The invention will now be described in more detail, by way of example, with reference to the drawings, in which

Figure 1 shows an injection-moulding plant for carrying out the method in accordance with the invention,
Figure 2 shows an embodiment of a mould during use of a variant of said method,
Figure 3 gives an example of the selected pressure as a function of time in the process of a variant of said method,
Figure 4 shows another embodiment of the mould,
Figure 5 shows a part of the mould shown in Figure 4 during a first step of a variant of said method,
Figure 6 shows a detail of the mould shown in Figure 4 during a second step of a variant of said method,
Figure 7 shows a detail of the mould shown in Figure 4 during a third step of a variant of said method,
Figure 8 shows a detail of the mould shown in Figure 4 during a fourth step of a variant of said method,
Figure 9 shows an embodiment of the mould in accordance with the invention during use of a variant of the method in accordance with the invention, and
Figure 10 shows the mould of Figure 9 during a subsequent step of the variant of the method in accordance with the invention.

[0009] It is to be noted that the embodiments are shown diagrammatically and the Figures are shown to an arbitrary scale, which is not always the same.

[0010] Figure 1 shows an injection-moulding plant for carrying out the method in accordance with the invention. The injection-moulding arrangement includes a gas supply arrangement 100, a mould 60, and a material supply arrangement 90, which is known *per se*. The gas supply arrangement 100 compnses a gas supply channel 73, which is connected to a first gas outlet 75 via a first gas control means 85 and to a second gas outlet 77 *via* a second gas control means 87. By means of this gas supply arrangement 100 gas from a supply vessel 71 connected to the gas supply channel 73 can be injected into a mould 60 *via* the gas outlets 75 and 77 and the gas inlets 51 and 52. The gas control means 85 and 87 include a plurality of parallel channels 79, which each have a pressure regulator 81 and an electrically controllable valve 83 by which the channels 79 can be closed. The pressure regulators 81 have a vent to bleed gas to the environment in order to allow the pressure to be reduced. By setting each of the pressure regulators 81 to a different value the pressure of a gas volume connected to the associated gas outlet can be adjusted to one of the preset values by opening one of the valves 83 and closing the other valves 83. To control the valves 83 the gas supply arrangement 100 comprises a control unit 89. This control unit 89 is constructed so as to enable at least two gas control means 85 and 87 to be controlled in accordance with a preset program.

[0011] Figure 2 is a cross-sectional view showing a mould 60. The mould 60 comprises an upper mould sec-

tion 61 and a lower mould section 62, in which a product cavity 10 and a spill cavity 20 are formed. The spill cavity 20 is in open communication with the product cavity 10 by means of a channel 30. A hot and consequently liquid matenal, in the present case a plastic 1, is injected into the mould 60 *via* a gate 63 and a sprue channel 9. The mould 60 has a first gas inlet 51, which opens into the product cavity 10. The mould 60 further has a second gas inlet 52, which opens into the spill cavity 20. In the product cavity 10 a gas volume 41 is formed by injecting gas *via* the first gas inlet 51. In the spill cavity 20 a second gas volume 42 is formed by gas injection *via* the second gas inlet 52. The material 1 at the wall 11 of the product cavity 10 cools rapidly by the contact with the wall 11. As a result of this cooling, the material near the wall 11 solidifies. The material in the central area of the product cavity 10 remains liquid for some time because its heat has to be carried off *via* the material 11 adjoining the wall 11. The still liquid material in the central area of the product cavity 10 is readily displaced by the gas injected *via* the first gas inlet 51. This results in a first gas volume 41, which forms a hollow space in the central part of the product. The content of the gas volume 41 depends on the amount of material 1 injected into the mould 60 and on the shrinkage of the material 1 during cooling. In a variant of the method in accordance with the invention the gas is injected simultaneously *via* the first gas inlet 51 and the second gas inlet 52. The gas injection *via* the first gas inlet 51 is effected with a higher pressure than the gas injection *via* the second gas inlet 52. Since the pressure in the first gas volume 41 is higher than in the second gas volume 42 at least a part of the liquid material between the two gas volumes is urged into the spill cavity 20. After a given time the pressure in the gas volume 42 is equalised to the pressure in the first gas volume 41. When the pressure in the two gas volumes is equal the volume of liquid material is no longer displaced. The amount of material flowing into the spill cavity 20 is determined by the pressure difference between the gas volumes 41 and 42 and the time during which this pressure difference is sustained. The material stream from and toward the spill cavity 20 can be controlled by varying this pressure difference and this period of time.

[0012] In the example shown in Figure 2 the channel 30 is connected to the product cavity 10 near a dead-end zone 13 of the product cavity. If the gas volume 41 does not extend entirely into the dead-end zone 13 of the product cavity 10 a solid portion is formed. Such a solid portion requires a longer cooling time. As a result, the time during which the product should remain in the mould 60 increases, so that the production costs of the product increase. Another disadvantage of a such a solid portion is that dunng cooling the material 1 may locally become detached from the wall 11 of the product cavity 10 as a result of material shrinkage. This gives nse to so called sink marks. A sink mark is a product area where the surface has sunk relative to other parts of the surface. Such a sink mark is very well visible and leads to a poor surface quality of the product. Such sink marks do not occur in the hollow parts of the product because the gas pushes the material 1 against the wall 11 of the product cavity 10. The mentioned measures enable the amount of material 1 flowing into the spill cavity 20 to be controlled exactly in such a way that the first gas volume 41 extends into the dead-end zone 13 of the product cavity 10.

[0013] Figure 3 shows an example of the pressure selected for the first gas volume 41 and the second gas volume 42 as a function of time in the process of a variant of the method. The pressure in the first gas volume 41 bears is referenced 111 and the pressure in the second gas volume 42 is referenced 112. As a result of these measures, material is urged into the spill cavity 20 during a first penod in the formation of the first gas volume 41 (see Fig. 2). During a second period material is urged back from the spill cavity 20 into the product cavity 10 in that the pressure of the gas in the second gas volume 42 is made higher than the pressure in the first gas volume 41. Urging the material back into the product cavity 10 further helps to prevent the occurrence of sink marks.

[0014] Figure 4 shows another embodiment of a mould 60 dunng a first step of another variant of the method. In this first step material 1 is injected to the product cavity 10. The shape of the product cavity 10 is such that the material is split into two material streams bounded by stream fronts 3 and 5. Moreover, the product cavity 10 has such a shape that the stream fronts 3 and 5 of the two streams of material meet at a location 15 in the product cavity 10. At this location 15 a channel 30 is connected to the product cavity 10, which channel 10 connects the product cavity 10 to a spill cavity 20. The mould 60 has a first gas inlet 51, which is situated in the sprue channel 9 and which terminates in the product cavity 10 *via* this sprue channel.

[0015] Figure 5 shows a part of the mould 60 of Figure 4. The stream front 3 and the stream front 5 collide at the location 15. In the absence of the channel 30 connecting the product cavity 10 to the spill cavity 20, the two material streams would not blend properly. This would result in a so-called flow line at the location 15. Such a flow line is visible at the product surface and gives the impression of poor quality. Moreover, the product is more likely to break at the location of the flow line because the molecules of the material are not crosslinked beyond the flow line.

[0016] Figure 6 shows the same part as Figure 5 but now during a second step of the variant of the method. The material streams reach the spill cavity 20 in that the channel 30 is arranged at the location where the material streams meet.

[0017] Figure 7 shows the same part as Figures 5 and 6 in a third step of the variant of the method. In this step the spill cavity 20 is wholly filled with the matenal 1. The two material streams have blended with one another

during filling of the spill cavity 20. The gas inlet 52 is arranged in such a manner that in the case of a filled spill cavity 20 it is wholly surrounded with the material 1. This minimises the risk of breakthrough of the gas, in which case gas would leak away to the environment. If the spill cavity 20 is not yet filled completely with matenal 1 at the instant that gas is injected into the spill cavity there will be a nsk that the gas breaks through the material and leaks away through an opening in the mould 60, so that the pressure does not remain at the required level. Owing to said measure the spill cavity 20 is properly filled with the material 1, so that an opening is closed by a layer of material, which is correctly supported at all sides by the cavity walls. The material is far more viscous than the gas and therefore cannot rapidly escape through a gap. The gas is thus trapped by the material.

[0018] Figure 8 shows the same part as Figures 5, 6 and 7 in a fourth step of a variant of the method. In the fourth step gas is injected into the spill cavity 20 via the second gas inlet 52 with a higher pressure than that in the product cavity 10. As a result, a gas volume 42 is formed and the material 11 is the spill cavity 20 is partly urged back into the product cavity 10 via the channel 30. This urging back ensures an even better blending of the streams of material, thereby preventing the formation of flow lines. Moreover, urging back of the material compensates for shrinkage of the material in the product cavity 10.

[0019] Figure 9 shows an embodiment of a mould 60 in accordance with the invention in the process of a variant of the method in accordance with the invention. The mould 60 has a product cavity 10 and a spill cavity 20 which are in open communication with one another by means of a channel 30. The product cavity 10 is filled with a liquid matenal 1 for 95 % *via* an injection nozzle 69. Subsequently, gas is injected *via* the first gas inlet 51, which is inserted into the injection nozzle 69, in order to form a first gas volume 41 in the product cavity. The pressure at the second gas inlet 52, which is inserted in the spill cavity, is smaller than that at the first gas inlet. The displacement of the still liquid material in the spill cavity 20 is controlled by controlling the pressure difference.

[0020] Figure 10 shows the mould of Figure 9 during a subsequent step of the variant of the method in accordance with the invention. In this subsequent step gas is injected into the spill cavity 20 *via* the second gas inlet 52 with a pressure higher than that existing in the first gas volume 41. This results in a second gas volume 42, which is separated from the first gas volume 41 by a volume of liquid material 12. By making the pressure in the second gas volume 42 higher than the pressure in the first gas volume 41 for some time the second gas volume 42 will extend into the product cavity 10. As a result, the still liquid material 12 will be driven to a location where the product requires a solid filling in order to obtain additional strength at this location. It is even possible to urge the still liquid material to and fro by alternately reversing the sign of the pressure difference between the gas volumes 41 and 42. A thin layer of material will then each time settle on the already solidified wall 17 of the hollow space in the product, so that the amount of liquid material 12 decreases. Eventually, the residual liquid material 12 can then be urged into the spill cavity 20 by making the pressure in the first gas volume 41 higher than the pressure in the second gas volume 42. This variant of the method in accordance with the invention provides an entirely hollow product for which the amount of material ultimately left behind in the spill cavity 20 is limited. This limitation allows the material in the spill cavity 20 to cool comparatively rapidly and less waste material is produced in comparison with a method in which the entire spill cavity is filled with material. Indeed, the material which solidifies in the spill cavity 20 is removed from the product and should therefore be regarded as waste.

[0021] Several other modifications are conceivable within the scope of the invention. For example, the mould 60 may have a plurality of spill cavities 20. Moreover, advantages of the invention can also be gained with embodiments in which the second gas inlet 52 terminates directly in the product cavity 10. In addition, the invention can also be used in injection-moulding or die-casting processes where the material 1 consists of a metal, a synthetic material filled with metal particles, or metal alloys.

Claims

1. A method for injection-moulding a product, including the steps of:

   - injecting an amount of a liquid matenal (1) into a mould (60) having a product cavity (10) defining the contours of the product,
   - forming a first gas volume (41) and a second gas volume (42) in the product cavity by injecting gas via a first gas inlet (51) and a second gas inlet (52), respectively, which first and second gas inlet are in communication with the product cavity,
   - allowing the liquid matenal in the product cavity to solidify, and
   - removing the product from the product cavity,

   characterised in that an alternating pressure difference is applied between the gas volumes (41, 42) such that the magnitude of the gas volumes alternately increases and decreases.

2. A method as claimed in Claim 1, characterised by driving the still liquid material to and fro between both gas inlets (51, 52) by alternately receiving the sign of the pressure difference if the gas inlets terminate in the product cavity (10) at some distance

from one another.

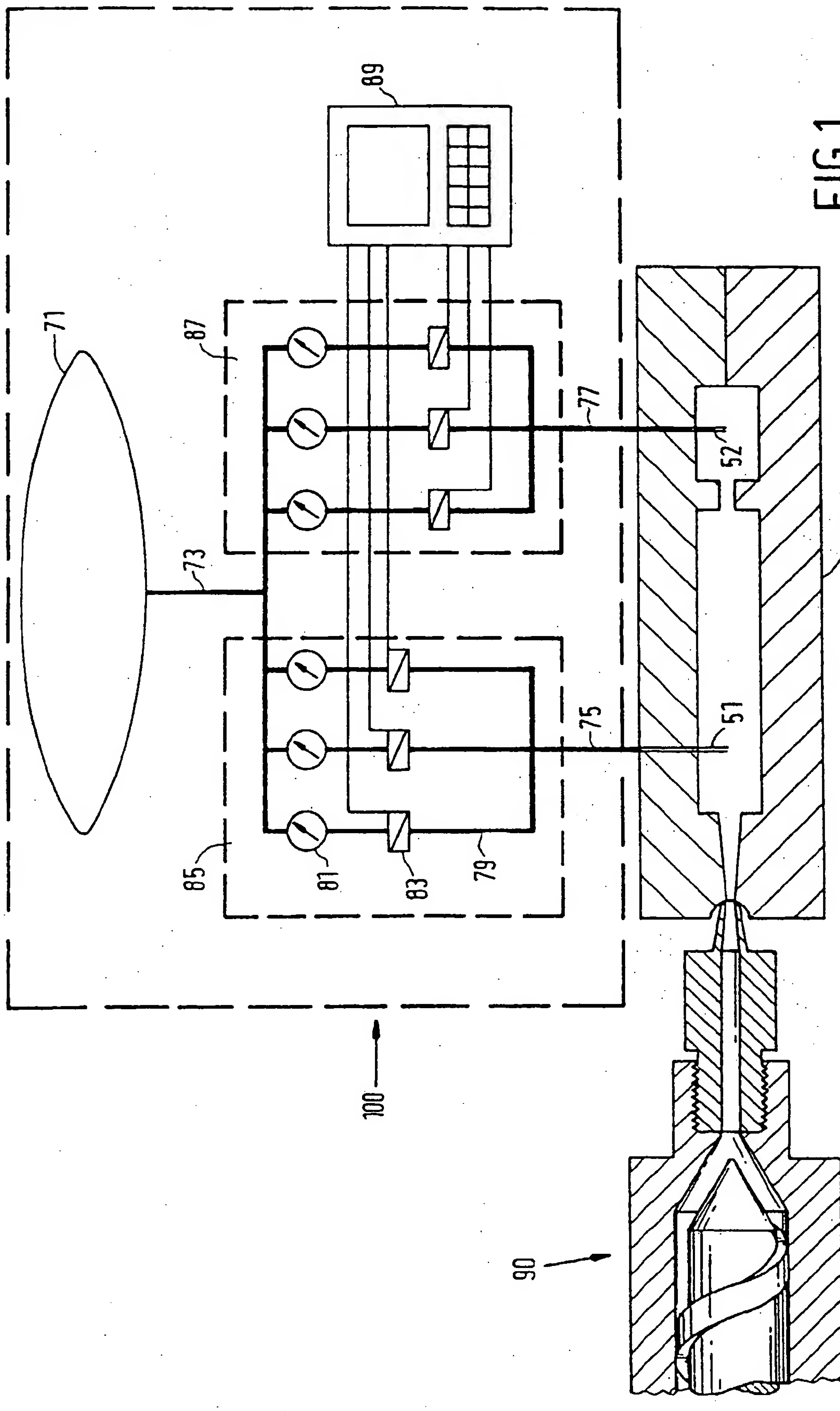

FIG.1

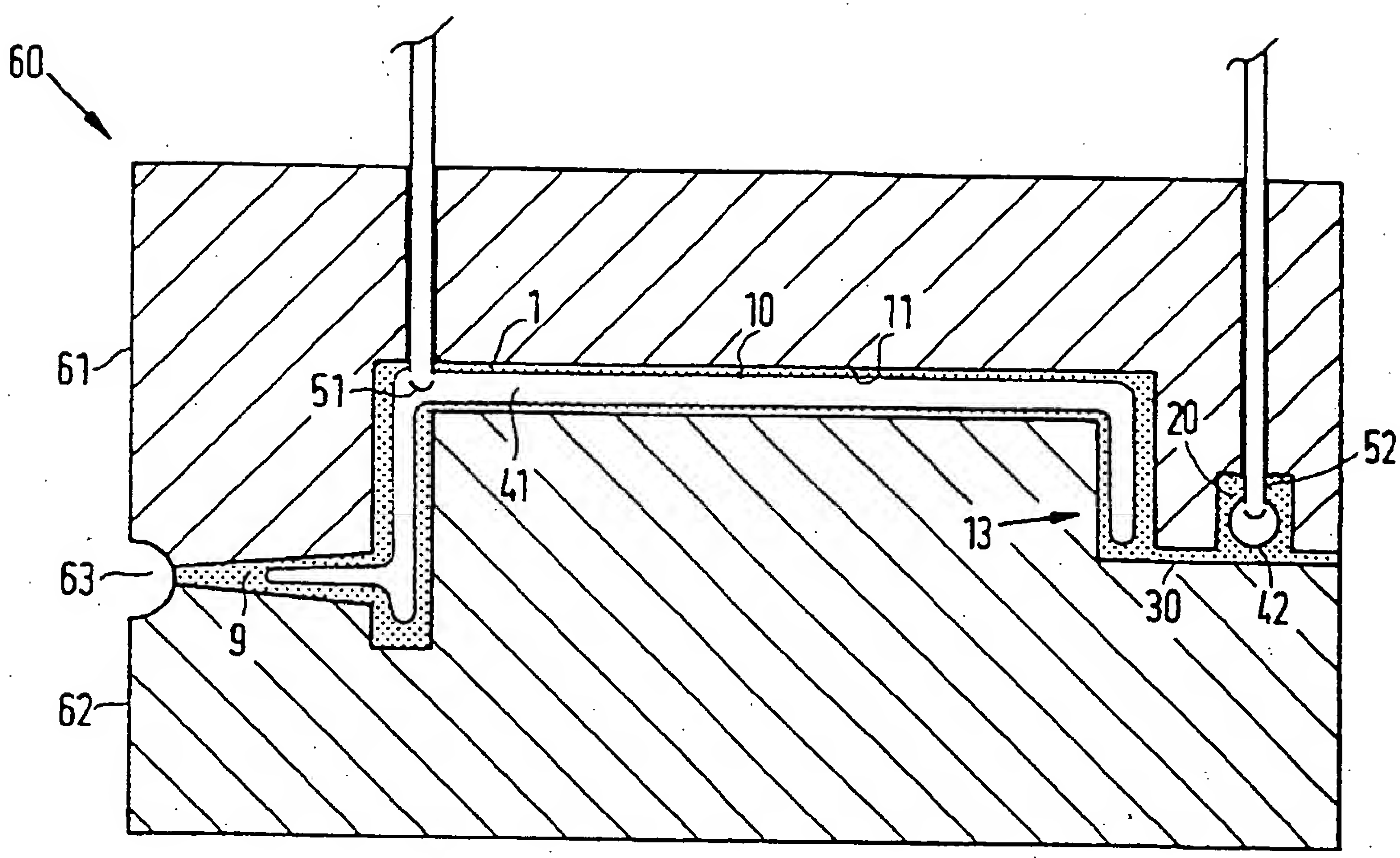

FIG. 2

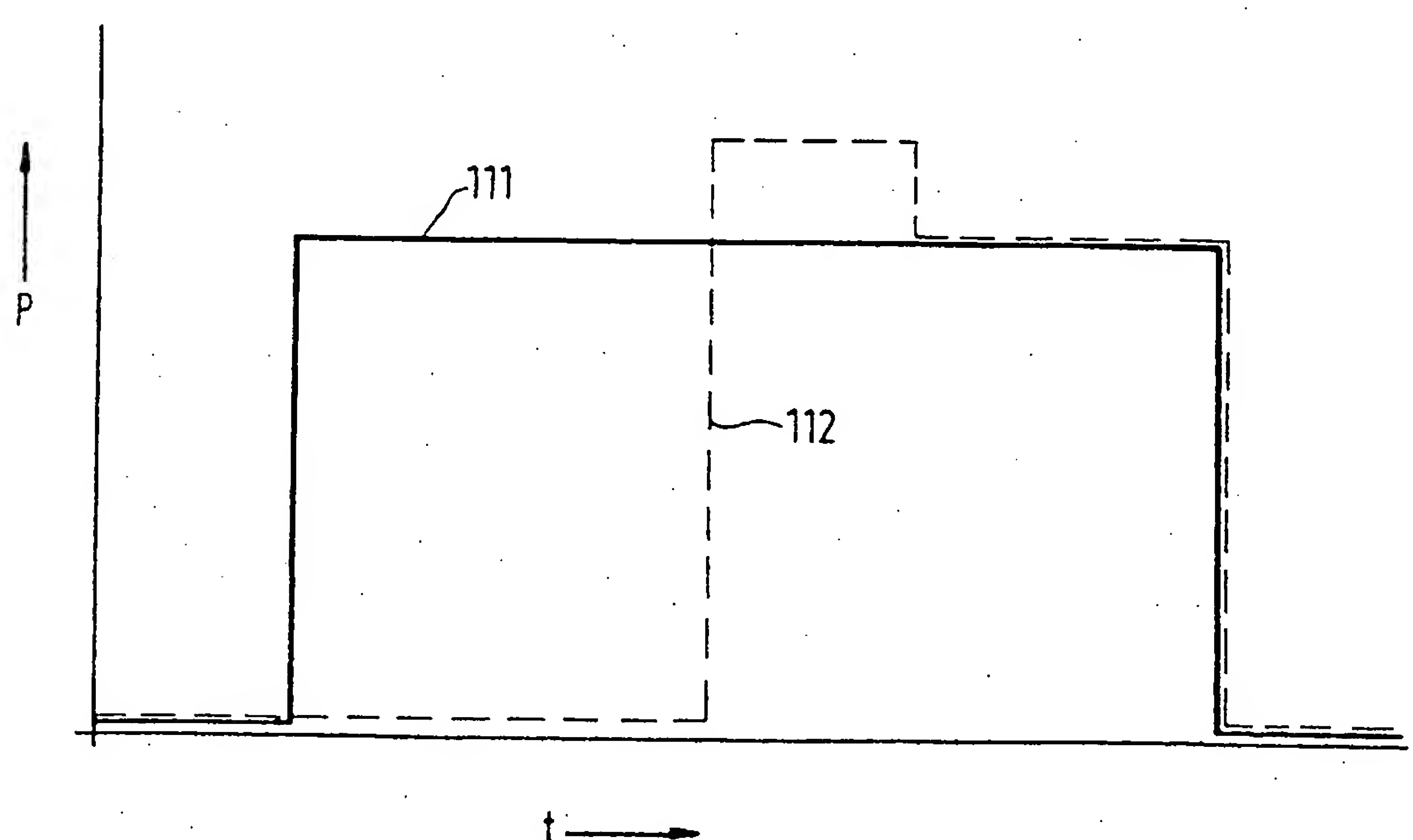

FIG. 3

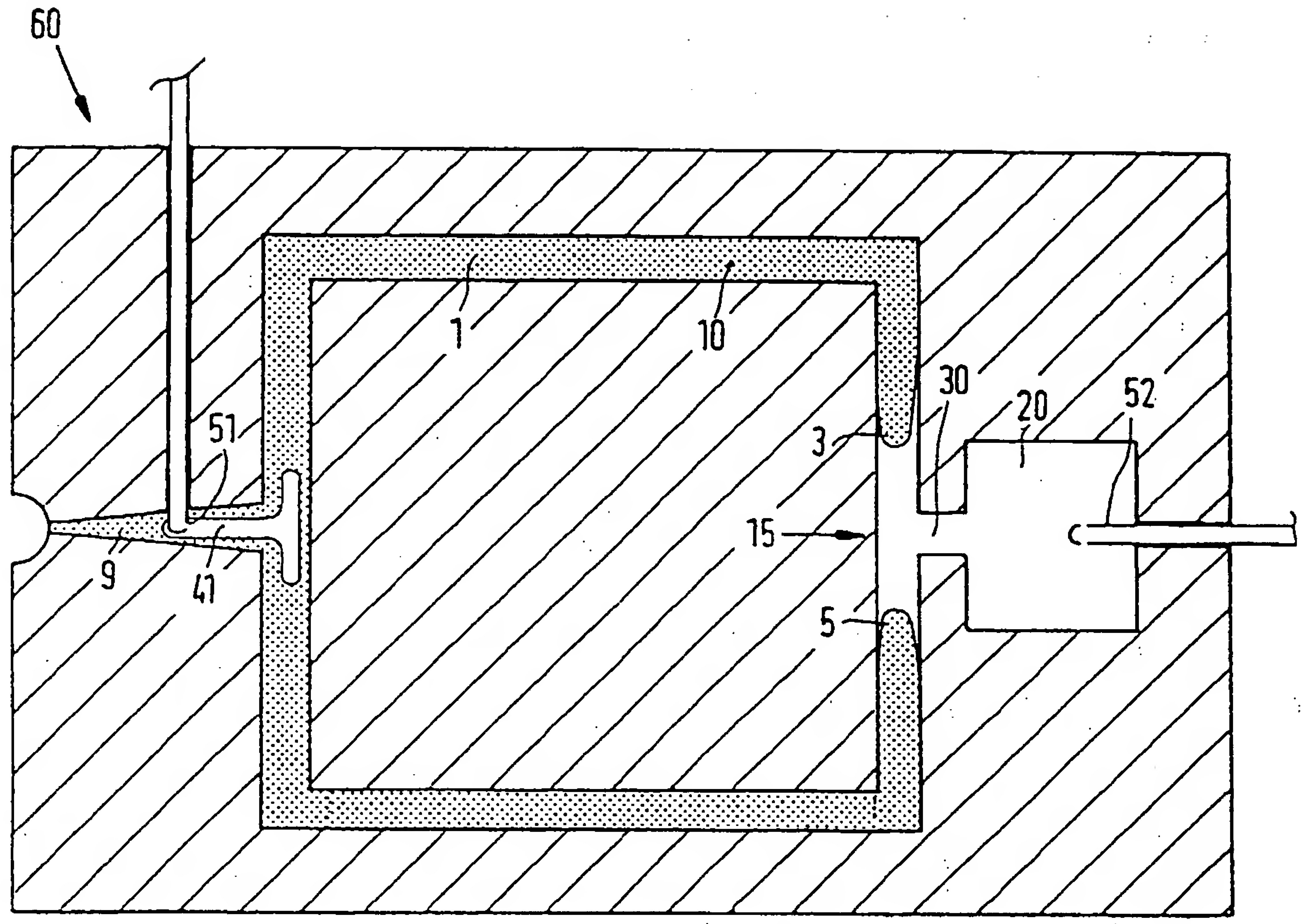

FIG. 4

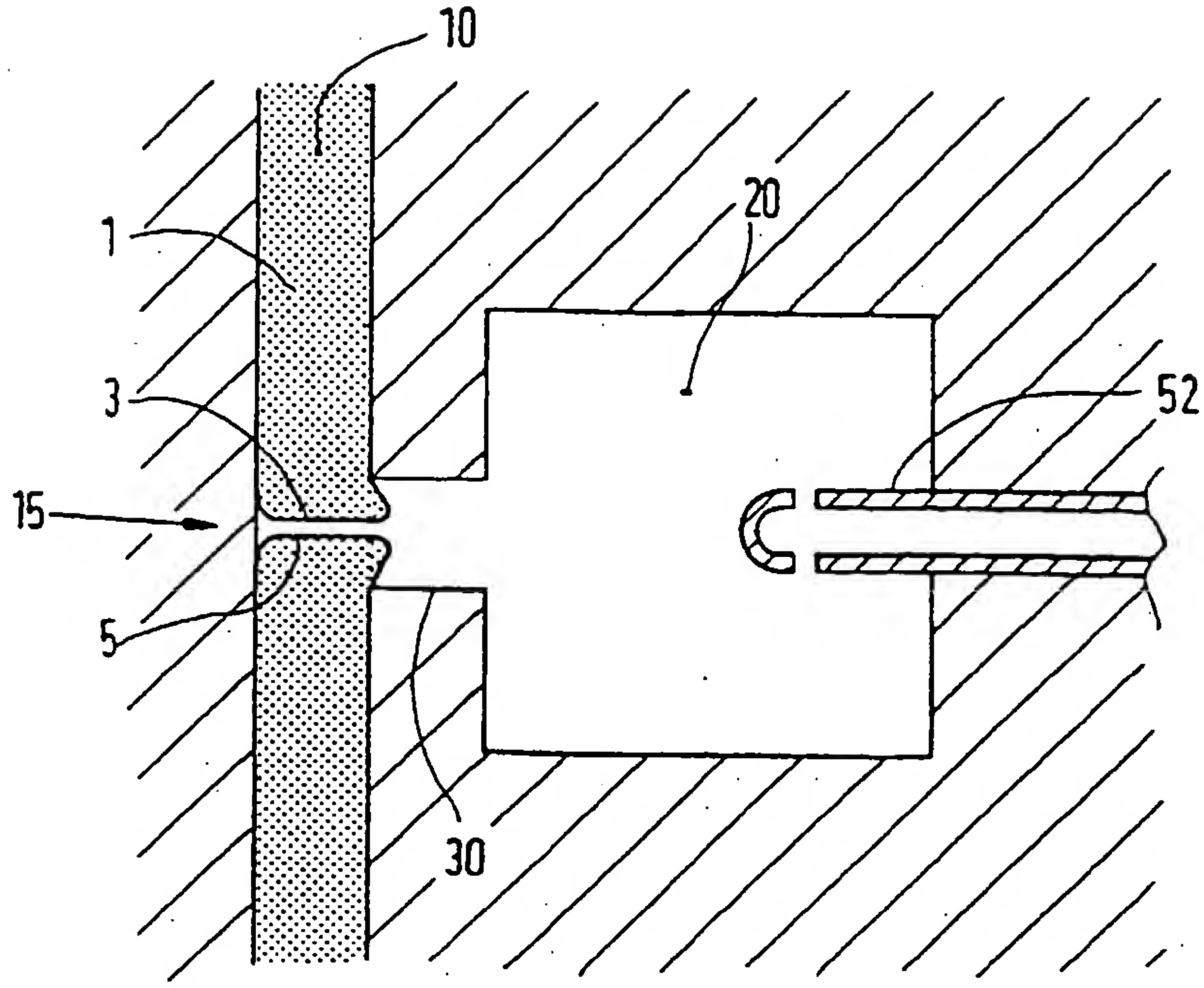

FIG.5

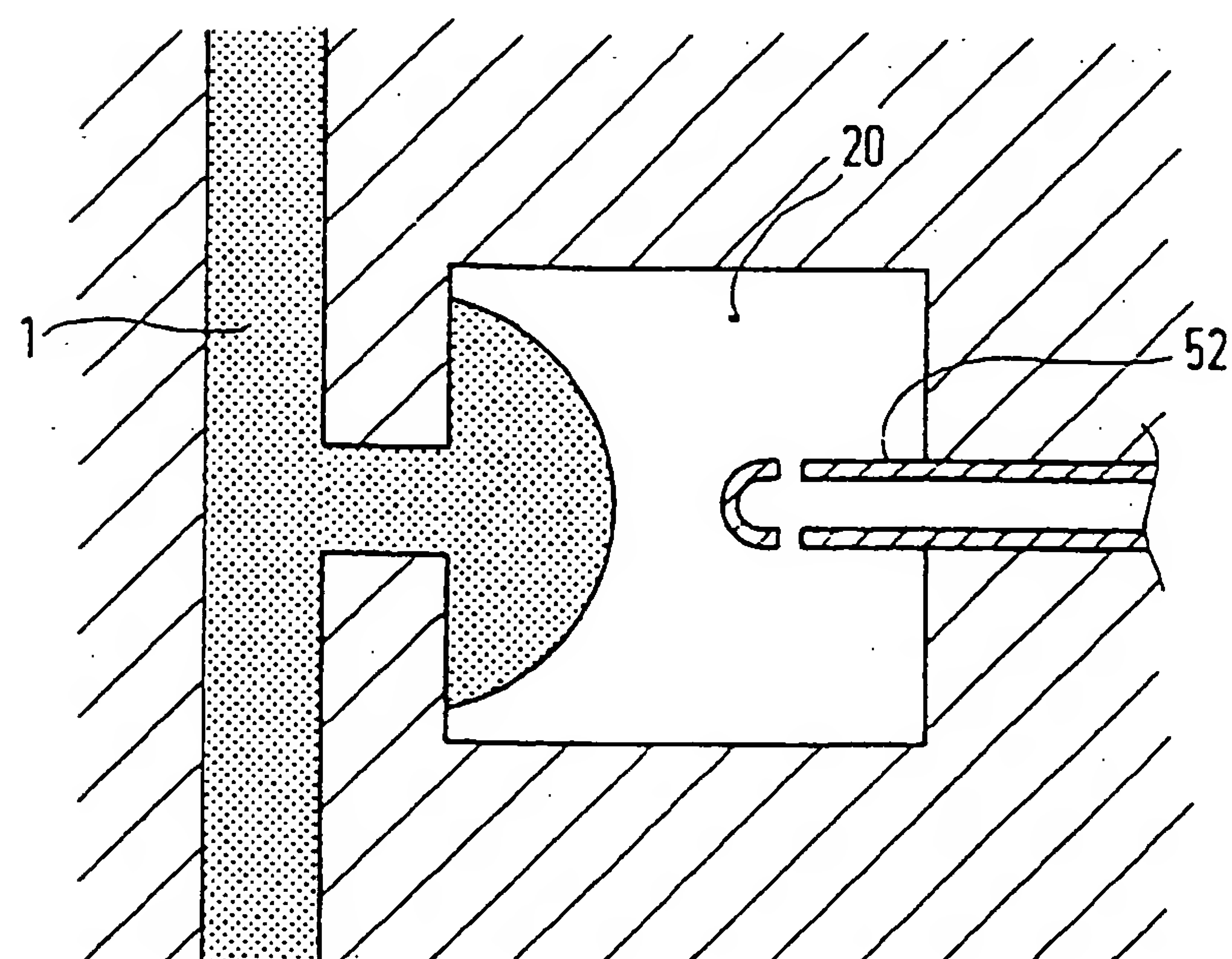

FIG.6

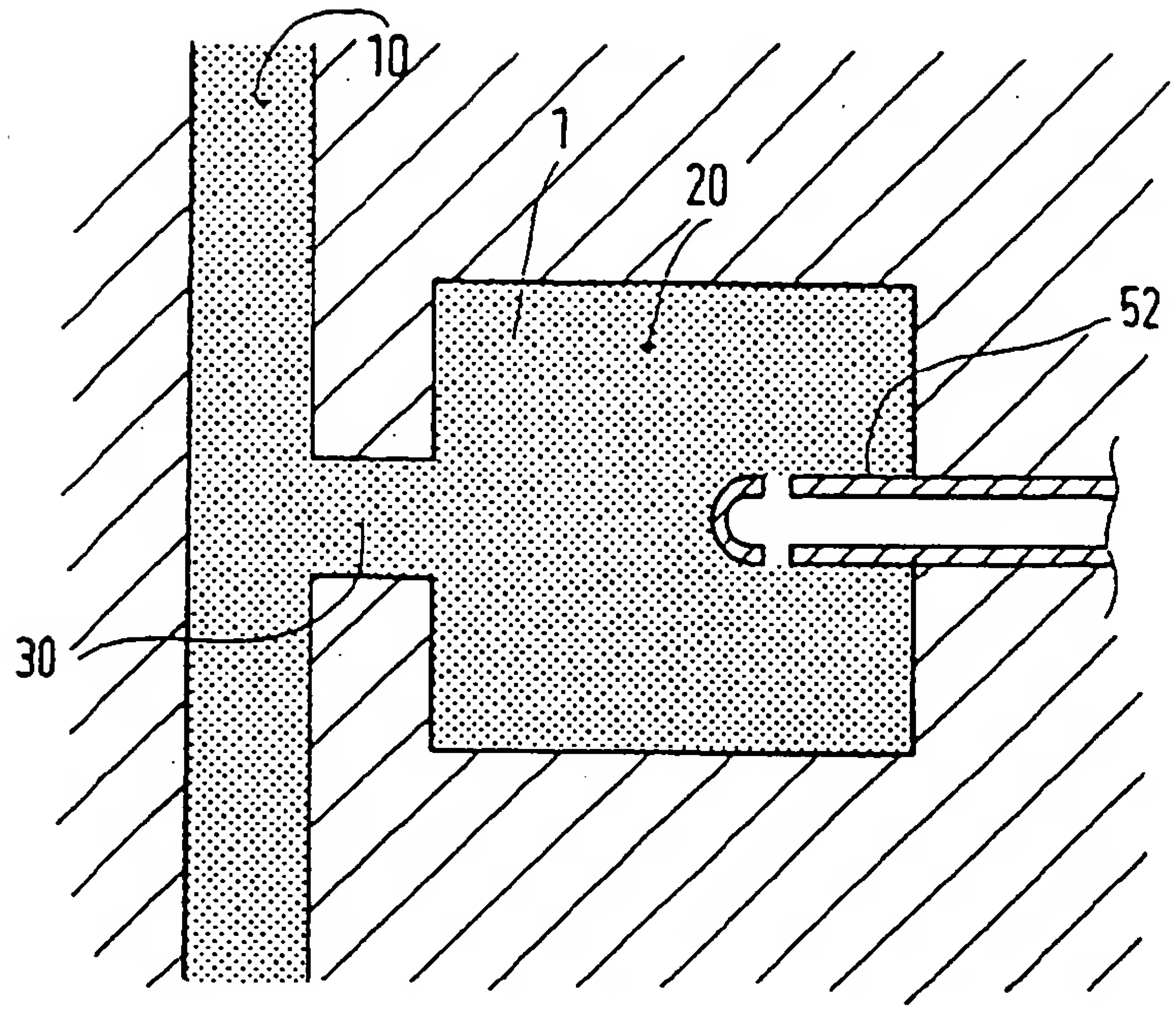

FIG. 7

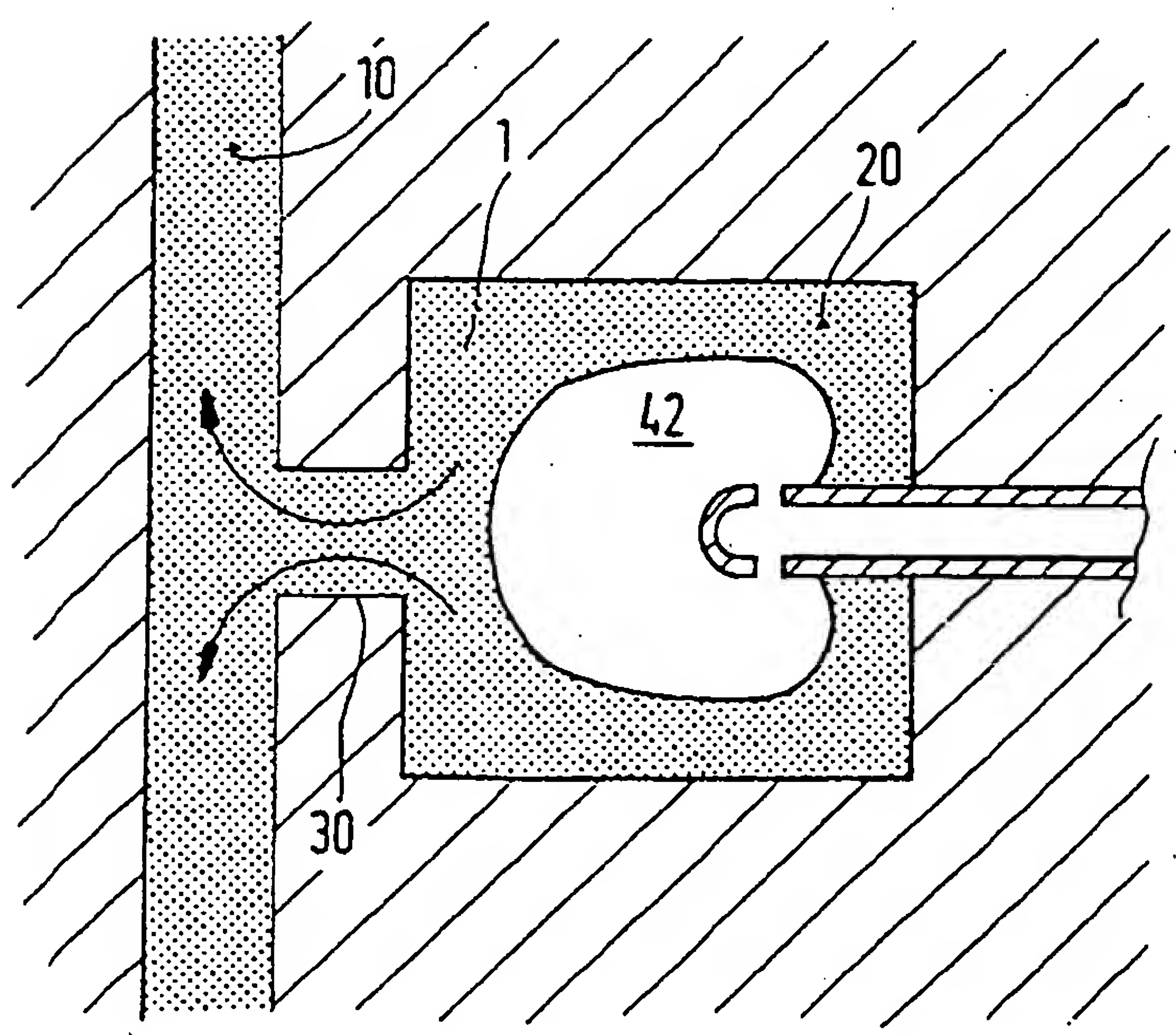

FIG. 8

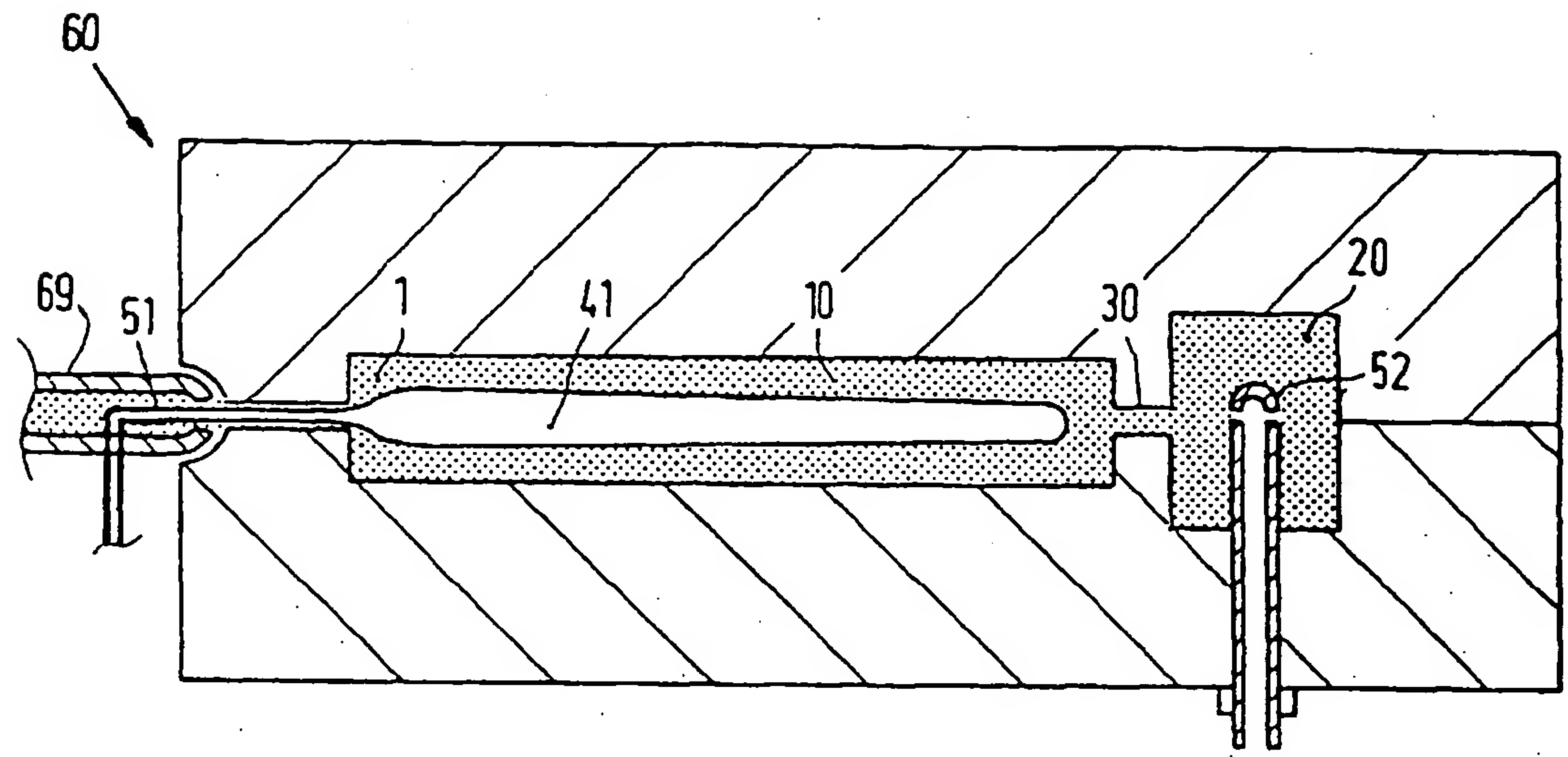

FIG.9

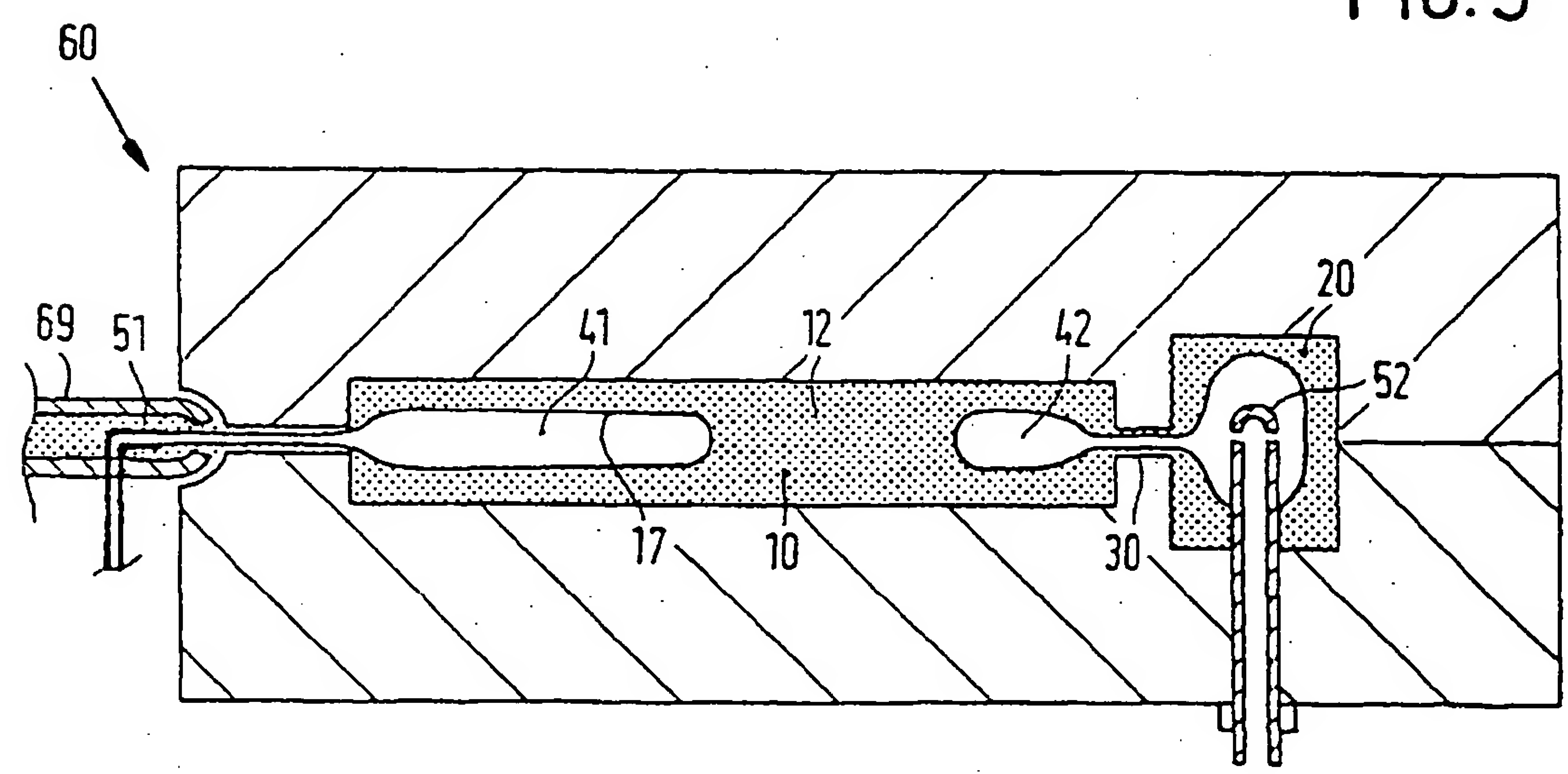

FIG.10

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EUROPEAN SEARCH REPORT

Application Number
EP 99 20 0120.6

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.6)
X	WO 9408773 A1 (BATTENFELD GMBH), 28 April 1994 (28.04.94) * page 4, line 9 - line 24; page 13, line 11 - line 20, figures 7,18 * --	1,2	B29C 45/17
X	US 5204050 A (NORMAN S. LOREN), 20 April 1993 (20.04.93) * column 2, line 30 - line 42 * --	1,2	
X	US 5098637 A (JAMES W. HENDRY), 24 March 1992 (24.03.92) * column 2, line 30 - line 36, figures 5,7, abstract * --	1,2	
A	DE 4316268 A1 (NINKAPLAST GMBH), 17 November 1994 (17.11.94) * column 2, line 25 - line 42 * -----	1,2	TECHNICAL FIELDS SEARCHED (Int. Cl.6) B29C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	22 April 1999	ERIC BJÖRKMAN

CATEGORY OF CITED DOCUMENTS

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